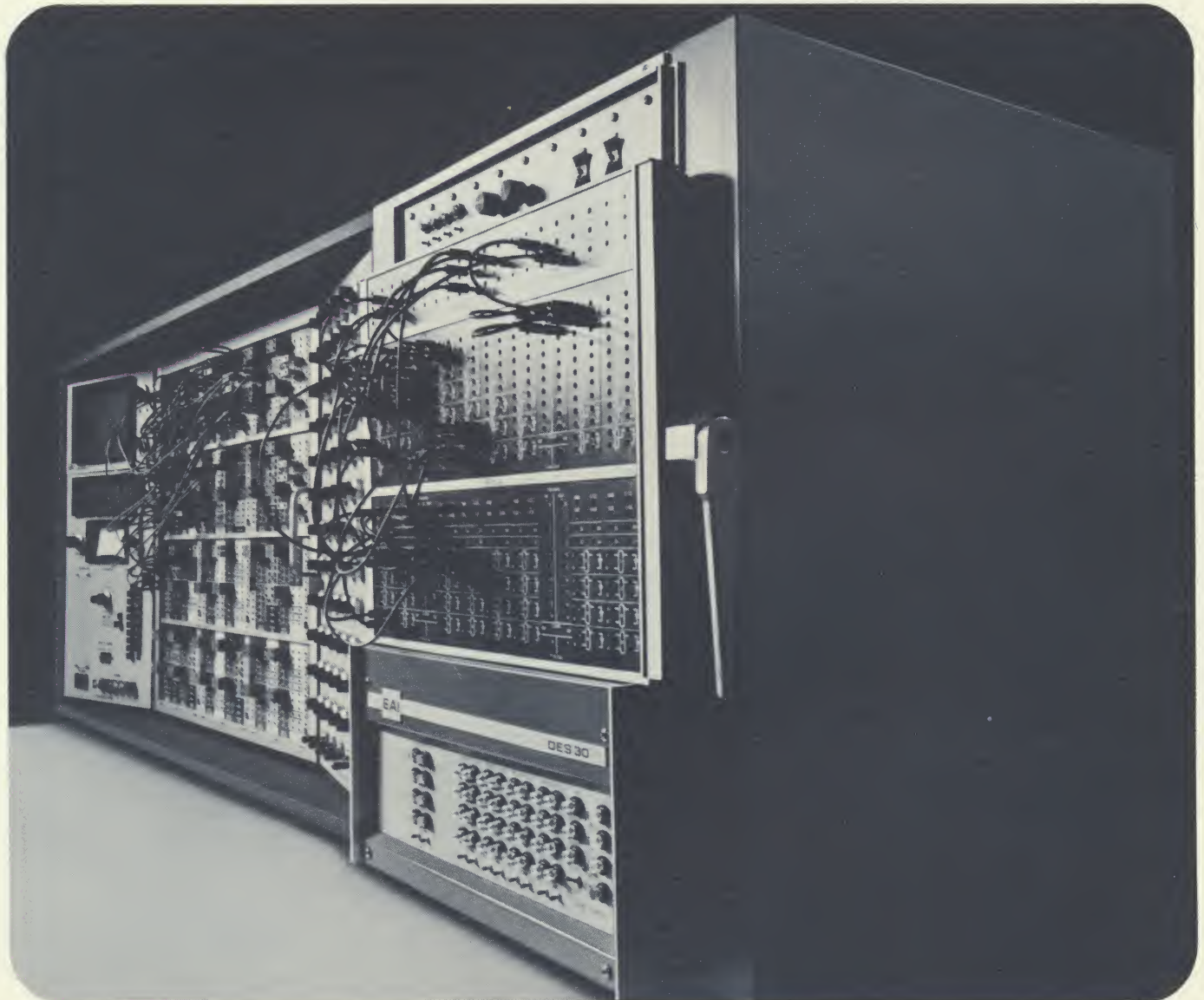


EAI[®] TR-20 TR-48/DES-30

Desk-top Analog/Hybrid Computing Systems

**For the ultimate in high-speed,
low-cost problem-solving capabilities**



The TR-20 and TR-48, together with their predecessor, the TR-10, are today's most popular desk-top analog computers. Over 1500 systems are presently in use performing as outstanding tools in education, research and design.

Extensive development of state-of-the-art components and systems capabilities provide today's TR-20 and TR-48 buyer with the most advanced computers in their class. New components and system features are also available for installation in all computers in the field. These continuous improvements protect the user against equipment obsolescence in a manner unequalled in the analog computer field.

As part of its extensive customer services, EAI gives free instruction courses with every purchase of a TR-20 or TR-48 computer, and also maintains an extensive analog and hybrid Applications Library available at no charge to users.



EAI TR-20 and TR-48 Computers Provide ...

■ **HIGH DYNAMIC ACCURACY** . . . the widest range of frequencies available in a desk-top computer.

■ **PROVEN SOLID-STATE CIRCUITRY** . . . instant warm-up . . . no cooling problems. Completely solid-state design based on their famous predecessor, the PACE® TR-10.

■ **OPERATOR-ORIENTED DESIGN** . . . each system is a complete self-contained computing center.

■ **10-VOLT REFERENCE SYSTEM** . . . greatest reliability, safety, and highest dynamic accuracy.

■ **CENTRAL VISUAL OVERLOAD ALARM** . . . immediate identification of amplifier overload.

■ **HIGH-SPEED REPETITIVE OPERATION** . . . for rapid design optimization and demonstration of the effects of parameter changes—change from real time to HSRO is accomplished without re-patching program.

■ **REMOVABLE PRE-PATCH PANELS** . . . providing greatest flexibility in patching and problem storage—bottle plugs greatly simplify patching.

■ **MODULAR PLUG-IN COMPONENTS** . . . versatility through a wide selection of interchangeable

computing elements which plug in from the front of the computers.

■ **COLOR-CODED PATCHING MODULES** . . . for simplified patching and maximum programmer efficiency.

■ **PRE-WIRED BASIC CONSOLE** . . . can be expanded simply by plugging in desired components—no additional wiring necessary.

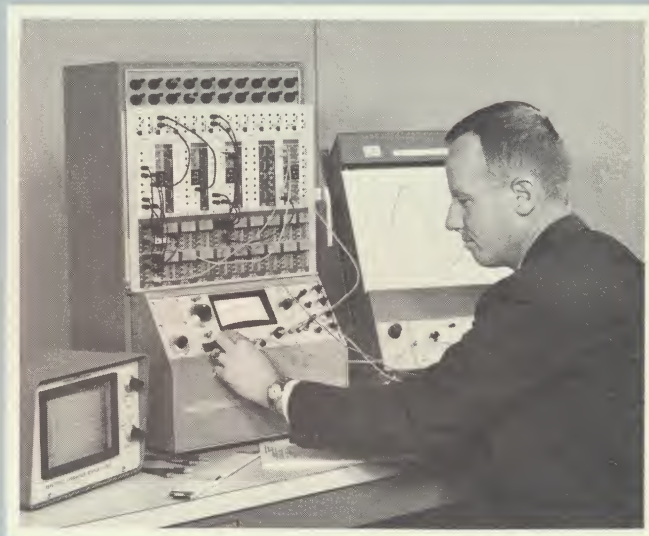
■ **RUGGED, RELIABLE, DAMAGE-PROOF DESIGN** . . . components and power supplies are protected and designed to be used by inexperienced, as well as experienced, operators.

■ **BUILT-IN RESISTORS** . . . all amplifiers are chopper-stabilized and include built-in input and patching-resistor networks matched to 0.01%.

■ **BUS BAR POWER DISTRIBUTION** . . . eliminates complex cabling and simplifies maintenance.

■ **NON-LINEAR COMPONENTS** . . . the widest range of fixed (for highest accuracy and no set-up time) and variable (for non-analytic functions) function generators available.

■ **PLUS** . . . the TR-20 and TR-48 Systems features on the following pages.



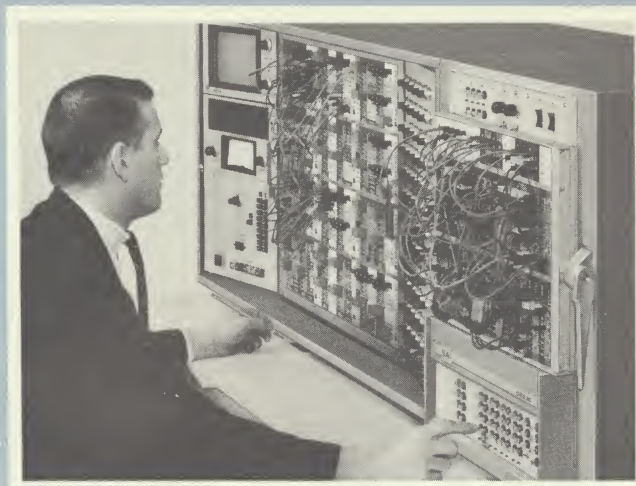
EAI TR-20 Computing System Highlights

- 20 AMPLIFIER CAPACITY . . .
- PORTABLE AND RUGGED . . . 15" x 16" x 27", 102 lbs. fully expanded
- PUSH-BUTTON POTENTIOMETER READOUT . . . speeds set-up and helps prevent errors
- BUILT-IN NULL VOLTMETER . . . provides direct reading or precision null reading
- SIMPLE ADJUSTMENT OF VARIABLE DIODE FUNCTION GENERATORS . . . slide-out drawers expose adjustments
- INCLINED CONTROL PANEL . . . for easy finger-tip control
- HIGH-SPEED REPETITIVE OPERATION DISPLAY . . . portable unit which displays four signals simultaneously
- LOW-POWER, GUARDED CIRCUITS . . . protect operator and computer. Requires less power than a 60-watt bulb, and plugs into any 115/220 V, 50-60 cps outlet.

The PACE® TR-20 is an all solid-state desk-top analog computer that puts proven high-speed computation at your finger-tips. Though compact in size, it is a full-fledged computer, capable of solving many complex problems previously requiring scheduling on large computing systems. It offers up to 20 amplifiers, plus components for addition, subtraction, multiplication, division, integration and generation of powers, roots, logs, antilogs, sine, cosine and arbitrary functions—in one cabinet, and available on one patch panel.

The TR-20 is useful in solving problems in such diverse areas as servo-system design, heat flow, chemical reaction analyses, suspension systems studies, simulation of living systems, and many other problems involving dynamic conditions.

With a TR-20 analog computer, you can explore problems as they occur with instantaneous visual readout—determining the feasibility of projects immediately—without leaving your desk. Simply turn a dial to feed in parameters, and the computer provides an instant, dynamic picture of the effect of each change. The endless drudgery of step-by-step calculation is eliminated—scientific data becomes alive.



EAI TR-48 Computing System Highlights

- 58 AMPLIFIER CAPACITY . . .
- WIDEST USABLE BANDWIDTH OF ANY DESK-TOP COMPUTER . . . amplifiers have no velocity limit to 96KC.
- RELAY OR ELECTRONIC MODE CONTROL . . . permits maximum utilization of high-speed, repetitive, iterative and hybrid techniques.
- FOUR INDEPENDENT TIME SCALE CHANGES . . . 1:1, 10:1, 500:1, 5000:1 available by automatic switching of capacitors within integrators.
- HYBRID EXPANSION WITH THE DES-30 . . . digital expansion system provides high-speed digital logic for advanced simulations.
- PUSH-BUTTON READOUT SYSTEM . . . provides rapid, positive selection of potentiometers for set-up and check, plus readout of amplifiers and trunks.
- SOLID-STATE DIGITAL VOLTMETERS . . . 4-digit or optional 5-digit voltmeter permits high accuracy and instantaneous display. High input impedance permits rapid direct pot setting.
- REP-OP SCOPE DISPLAY . . . installs in the console above the digital voltmeter display and is conveniently addressable from the computer's flexible readout system. Displays four signals simultaneously.
- HIGH-SPEED ELECTRONIC COMPARATORS . . . performing the functions of a comparator, electronic D/A switch, or track and store network, these modules provide advanced computation capability. They may be controlled by analog voltages or digital logic signals from the DES-30 or external devices.
- COMPACT AND MOBILE, LOW-POWER DRAIN . . . sits on any desk and plugs into any 115/230 V, 50-60 cps outlet. Power drain is less than a 150-watt bulb.

The most complete desk-top analog/hybrid computer available—solving sophisticated problems, such as those requiring high-speed repetitive operation, iterative techniques and multi-speed computation with a capability equal to that of many console computing systems. The TR-48 and DES-30 are solid-state designed for long-life reliability.

The TR-48 is available in any complexity, from a basic unit to simulate linear systems to a unit to provide the most complicated non-linear simulations. Addition of the DES-30 Digital Expansion System provides flexible hybrid expansion capability.

All computing components plug in from the front for simplified system set-up, regardless of complexity. TR-48 computers are readily "slaved" for even greater extension of system capabilities.

Typical applications of the TR-48 are: system optimization, boundary value problems, model building—including portions of the anatomy for biomedical investigations, rapid determination of stability of control systems, approximate computation and display of integral transforms, statistical studies requiring many solutions, and a wide variety of routine computation problems requiring multiple solutions.

Every operational feature of the TR-48 and DES-30 is human-engineered to the maximum to simplify operational training and the actual programming. Your present personnel can learn to operate and program without elaborate training, and discover the multiple benefits in shortcutting time to solution of their most intriguing problems while cutting cost in research and in the engineering of optimum products.

Analog and Hybrid Simulation...

Analog and Hybrid Simulation are dynamic methods of solving the problems that confront the engineer and scientist daily—and EAI TR-20 and TR-48 Analog Computers and the TR-48/DES-30 Hybrid System provide an unsurpassed capability for simulating systems of all types. EAI computers help slash project costs by saving time and material in trial and error testing of prototypes or pilot plants. One engineer with a desktop PACE® computer can be the equal of several men limited to conventional design tools; more-

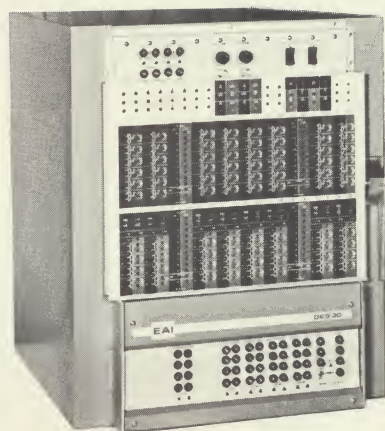
over, he can gain a unique insight into the dynamic performance of systems to produce a superior product.

Experimentation time and costs are slashed. Ideas that were once too costly or time-consuming to be tried can be "debugged" right on the computer. Parameter changes are dialed in—simply change potentiometer settings, output changes are instantaneous. Analog and Hybrid computation actually stimulate creativity.

Areas of Application

- ADVANCED PROBLEM SOLVING AND TEACHING OF COMPUTATION TECHNIQUES IN UNIVERSITIES AND TECHNICAL SCHOOLS
- SIMULATION OF PHYSICAL SYSTEM BEHAVIOR FOR CLASSROOM DEMONSTRATION
- SIMULATION AND CONTROL IN THE PROCESS INDUSTRY
- DATA REDUCTION AND PHYSIOLOGICAL MODEL BUILDING IN THE LIFE SCIENCES LABORATORY
- SYSTEM SIMULATION IN THE AEROSPACE INDUSTRY





Digital Expansion System - DES-30

The DES-30 is a low-cost digital logic expansion to the TR-48, providing hybrid capability for the desk-top computer user. In combination with the TR-48, the DES-30 enables the solution of problems far more complex than previously possible

with computers of the TR-48 size. The DES-30 may be obtained with the TR-48, or added to an existing TR-48 system. It is completely practical to start with an analog system and add the DES-30 in the future.

■ **SYNCHRONOUS LOGIC** . . . logic operations are timed from internal clock, or may be triggered by an external signal. One megacycle clock.

■ **REMOVABLE PATCH PANEL** . . . allows the storage of logic routines. Panel is clearly marked with logic symbols. Special "piggy-back" patch cords are used for easy patching.

■ **EASILY EXPANDED** . . . all components are modular plug-in units allowing fast expansion. Basic frame is completely wired for full expansion capability.

■ **SELF-CONTAINED** . . . unit supplies its own power and may be used by itself as a digital logic trainer.

■ **LOGIC INDICATOR FIELD** . . . contains a logic state indicator for each logic storage element in the DES-30.

■ **EASY PROGRAM CHECKOUT** . . . logic may be manually stepped for ease of program checkout.

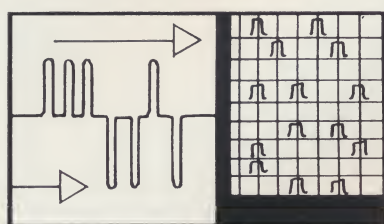
■ **MULTITUDE OF PLUG-IN MODULES** . . . gates, flip/flops, registers, counters, and monostables.

EAI[®]

ELECTRONIC ASSOCIATES, INC. *West Long Branch, New Jersey*

ADVANCED SYSTEMS ANALYSIS AND COMPUTATION SERVICES/ANALOG COMPUTERS/DIGITAL COMPUTERS/HYBRID ANALOG-DIGITAL COMPUTATION EQUIPMENT/ANALOG AND DIGITAL PLOTTERS/SIMULATION SYSTEMS/SCIENTIFIC AND LABORATORY INSTRUMENTS/INDUSTRIAL PROCESS CONTROL SYSTEMS/PHOTOGRAMMETRIC EQUIPMENT/RANGE INSTRUMENTATION SYSTEMS/TEST AND CHECK-OUT SYSTEMS/MILITARY AND INDUSTRIAL RESEARCH AND DEVELOPMENT SERVICES/FIELD ENGINEERING AND EQUIPMENT MAINTENANCE SERVICES.

A "TRUE HYBRID" STORED-PROGRAM SIGNAL PROCESSOR



by Thomas G. Hagan, Vice President,
Adage, Inc., Cambridge, Massachusetts

DATA SYSTEMS ENGINEERING STAFF COMMENT

Continuing our coverage of the "hybrid" computer concept, as it rapidly develops, both in the number and quality of available design approaches, we present here the first commercial offering of a standard, completely modular, integrated data-processing and computation machine of the "true hybrid" type, to use language consistent with Mr. Truitt's article in last month's DSE ("Parallel-Analog, Sequential-Digital, & True-Hybrid Computers").

Our readers will also recall our earlier exposition ("A Flexible Hybrid-Computer Linkage System", November 1963) of the hybrid computer linkage equipment designed by the same engineering group that has produced the Ambilog 200 discussed herein.

To quote from our editorial in the February issue: "The hybrid computer, in various forms, and various price ranges, is rapidly becoming the project of greatest interest in most of the major data-processing companies, and will soon constitute, in our opinion, a significant portion of the market for data systems. This is true despite the fact that the hybrid appears at present to have only limited applications, and then only to relatively "exotic" problems. Actually, that appearance is misleading, as we shall see in the months and years to come."

A DEFINITION

An ambilogical device is defined as one that "knows" both analog and digital signals. As used in this description, the term Ambilogical Computing Element (ACE) will refer to a particular ambilogical device that performs arithmetic operations on both analog and digital inputs, and produces an analog output. Other useful ambilogical devices include the analog-to-digital converter (ADC) and the digital-to-analog converter (DAC), although, as we shall see, the DAC function can be performed by the ACE.

The equivalent circuit of the ACE modules used in the true-hybrid Ambilog 200 to be described herein is shown in Figure 1. This equivalent circuit is greatly simplified, although no functional capability has been omitted. It can be seen that the fundamental multiply/divide function is performed by digitally programming the coefficient-determining resistors of an operational amplifier, the input signal for which is developed by a preceding operational amplifier that performs as an operational adder, also digitally programmable.

The capability of the Ambilogical Computing Element, then, can be seen to be quite wide in scope. It accepts multiple analog inputs, a 15-bit parallel digital data word, and 7 digital control bits. It delivers an analog result. Six of the digital control bits are used to specify those analog inputs to be included in a summing operation. The state of the seventh control bit determines whether this sum is multiplied by or divided by the 15-bit digital data word. For analog inputs, m , n , p , q , r , s , and digital input value A , appropriate control bit combinations permit arithmetic operations such as $(m + p) A$, or $(m + n + p + s)$, or, simply, $r \times A$.

A

While there is actually nothing novel in the individual circuits used in the ACE module, the combination of data manipulation facilities that it makes available is particularly fortuitous, and has simplified the construction of a "true-hybrid" stored-program data processor . . . the Ambilog 200.

THE AMBILOG 200 SYSTEM

The Ambilog 200 is a stored-program data processing system, designed especially for data acquisition and reduction systems involving one or more analog inputs and requiring analog and/or digital outputs.

The Ambilog 200 Signal Processor is a true hybrid and is believed to be the first data-handling system to be offered as a standard product that has

been designed "from the ground up" to exploit the potential of fully hybridized operations.

The new machine is organized to permit parallel use of multiple-hybrid (ACE) arithmetic units for high processing speed. A typical operation time for simultaneous addition and multiplication or division is 10 microseconds. A wide range of input-output capabilities is provided in both analog and digital domains by solid-state analog-signal multiplexers, analog signal conditioners, typewriter, and both punched-paper and magnetic tape units.

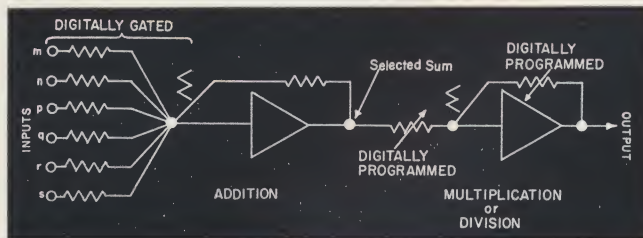


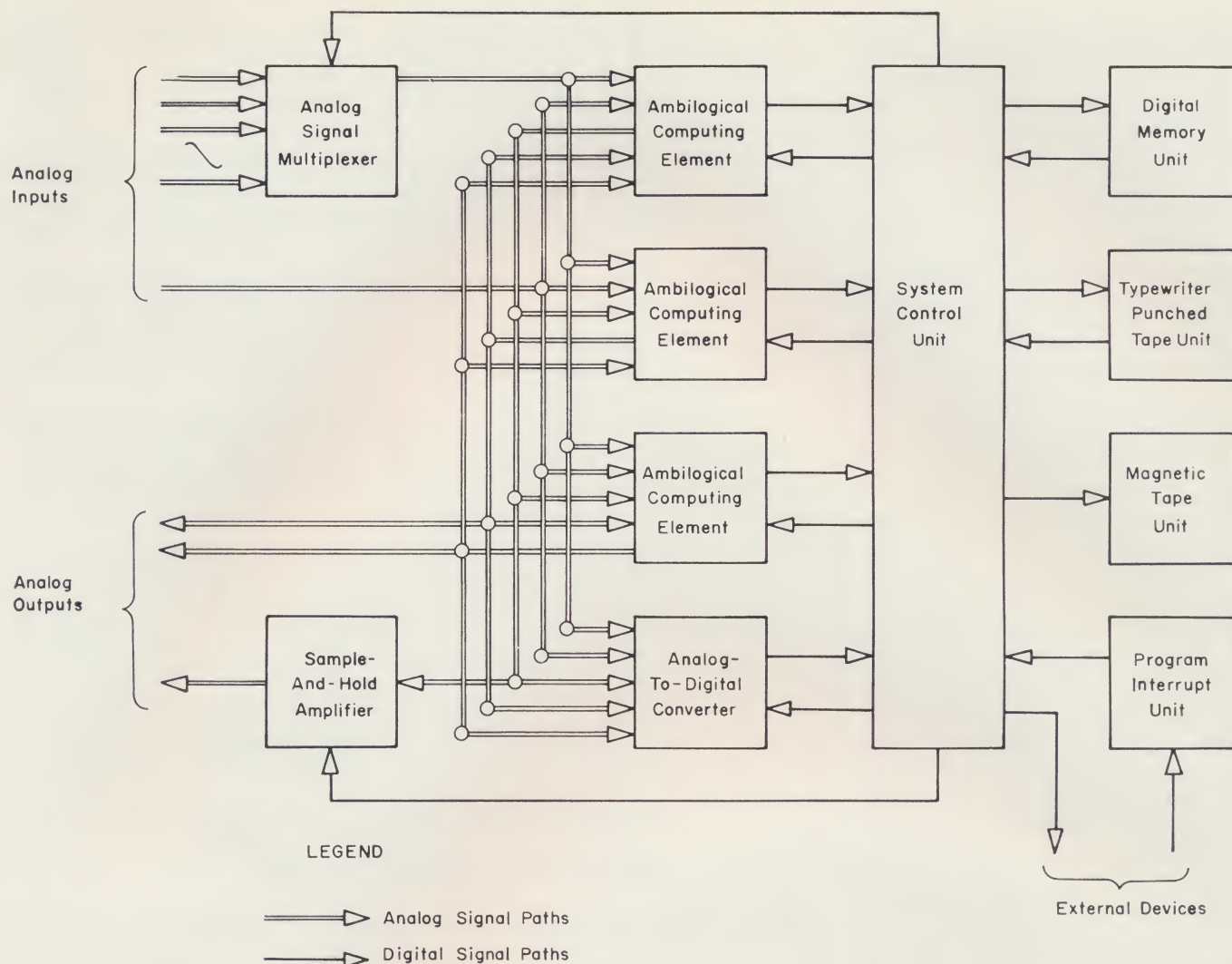
Fig. 1

The stored-program design provides unusual flexibility for the user. A system can be changed to accommodate new computing or simulation problems merely by changing the program. Modular design and organization of the hardware also allows easy expansion to meet increased problem requirements. Use of completely standardized subsystems leads to lower manufacturing costs and lower prices than less-flexible, one-of-a-kind systems.

These standard subsystems may be combined in many different useful configurations. A typical system organization is shown in Figure 2. This particular configuration can acquire and process data from multiple analog channels, provide analog outputs for monitoring displays, and produce digital magnetic tape for future computer input and analysis. It has program-interrupt capability for effective real-time operation.

The heart of this system is the parallel array of Ambilogical Computing Elements, whose interconnections and functioning are controlled by the System Control Unit, in response to the program stored in the Digital Memory Unit. Various combinations of Ambilogical Computing Elements, Analog-to-Digital Converters, and Digital-to-Analog Converters may be used in a particular system, and plug-in replacement is possible. Even greater flexibility derives from the stored-program control and high-speed electronic switching of the configuration during operation.

By means of its parallel and ambilogical arithmetic operation, the Ambilog 200 achieves notably high speeds



even for complex processing of incoming analog signals. Equipped with three ACE's, the Ambilog 200 can accomplish, for example, 12 additions, 2 multiplications, and a division, all in 10 microseconds. In addition, provision is made for comparing digital and analog values without complete analog-to-digital conversion, so that limit-testing, peak-detecting, and similar functions can be performed at higher speeds than would be possible if each function required a complete A-D conversion.

To make effective use of the high-speed operations in the ambilogical and analog portions of the system, the Digital Memory Unit reads and writes double-length words in a basic 2 microsecond cycle time. Each word in the memory can store either one 30-bit instruction, one 30-bit value, or two 15-bit values. Digital data transfers are possible at rates up to 125,000 characters per second. Memory modules are available in sizes of 1K, 2K, 4K, 8K, 16K and 32K, 30-bit words. Memory locations are directly addressable up to 32K words. The System Control Unit is capable of performing a basic set of digital

arithmetic and logical operations, plus an extensive set of digital data transfers. A micro-coded instruction format, plus recursive indirect addressing and indexing, permit the programmer to take full advantage of the inherent flexibility of the Ambilog 200 design. A Symbolic Assembly System is provided, with a library of standard programs and subroutines large enough to satisfy a majority of the most commonly-encountered user needs.

Manual operating control and digital data entry are by means of the input-output typewriter. Display of digital register contents is provided in each of the appropriate subsystems, with an Operator's Control Panel for local or remote control and monitoring use. Display subsystems are readily integrated into the Ambilog 200 for applications requiring their use.

Multiplexing, storage, and conditioning of analog inputs and outputs is accomplished by standard subsystems, all of which have had several years of field experience in related applications.

TYPICAL APPLICATIONS

The Ambilog 200 is specifically designed for use as a signal processor in

systems involving various combinations of analog and digital inputs and outputs. It is particularly well suited to such applications as biomedical data acquisition and signal processing, test-stand instrumentation, programmed automatic checkout, high-speed factory test and inspection, seismic-waveform analysis, and for use as a research tool in the field of communications.

Waveform Analysis: Analog input signals may be analyzed during data acquisition, and only data of further interest need be recorded for later computer processing. Simple examples of such analysis include: limit-testing, peak-reading, running averages, normalization, and data-controlled variable sampling rates. The machine is also useful for complex signal analyses, such as probability distributions and time-domain filtering.

Pattern Recognition: Stored-program flexibility and availability of previous values in digital storage make this device useful in pattern-recognition work. Of particular value is the capability of performing ambilogical arithmetic on incoming signals and testing the result without performing a full

analog-to-digital conversion. Thus, an incoming signal can be compared to a stored pattern at higher rates than would be possible by more conventional computer techniques.

Signal Generation: Extremely complex and completely reproducible analog signal outputs can be generated by the Ambilog 200 from stored digital control data. This capability can be used for time expansion and compression of analog inputs, or to produce standard signals for test and control applications.

Simulation: The flexible and expandable analog and digital input-output interfaces of the Ambilog 200 make it a powerful tool for simulation work. Its high internal digital speeds rival those of the faster general-purpose digital computers, while its ambilogical arithmetic and logical capabilities make possible still higher speeds.

Data Acquisition: With its stored-program flexibility and high speed, the Ambilog 200 is an economical solution to many data acquisition problems. Complete flexibility of input multiplexing and magnetic tape formatting, plus the capability of screening and normalizing data, often make the Ambilog 200 less expensive than a special-purpose system for a single application.

Real-Time Data Processing: The high internal speeds and program-interrupt capability of the Ambilog 200 make it a powerful tool in many real-time applications, including medical monitoring, process control, automatic testing and time-shared computer systems. Real-time operation is facilitated by a novel multiple-priority program interrupt system. Each external program interrupt channel serves as the source for a single instruction, which may be executed between two consecutive instructions being read from memory. Each interrupt channel has a bank of switches into which the desired 30-bit instruction is set manually. In response to an interrupt, this instruction is loaded into the instruction register. The interrupt instruction may be the usual "jump to subroutine," or other instructions may be used to accomplish other functions instead. Any number of such interrupt channels may be connected in series. Their relative priorities correspond to their relative positions in the series.

The Ambilog 200 is organized in modular form, with prices beginning at about \$75,000. Comprehensive software support includes programmer and maintenance training, installation and maintenance services, standard subroutines, system programs, and a symbolic assembly system. ■ ■

EAI TO SIMULATE AND CONTROL ON-LINE CHEMICAL PROCESSAT SYSTEMS ENGINEERING EXPOSITION

NEW YORK, N. Y. --- A complex feedforward feedbackward chemical control system is being simulated by Electronic Associates, Inc. at the first Systems Engineering Exposition in Booths 327 and 331, New York Coliseum, June 8 through 11, 1964.

Using a TR-48 desk-top analog computer, and a PC-12, process control computer, EAI is demonstrating on-line control of product composition and temperature in a continuous flow stirred-tank chemical reactor. The reactor system is fed by two pure streams of reactants, X and Y, which form the product Z. The reaction is exothermic, so temperature control is effected by varying the flow of cooling water to both a surrounding jacket and an immersed coil. Reactor holdup is adjusted by the PC-12 computer to maintain product purity. The computer is programmed to manipulate the flow of the reactants and to control reactor temperature and volume.

A PDS-1068 digital computer is used for the data logging and display of information in the form of tape or typewritten copy from which cost of making the product can be determined. In addition, the information is transferred into graphic display on a digital X-Y plotter (DATAPLOTTER).

According to EAI engineers, combination feedforward feedback control systems can offer significant improvements in the performance of systems displaying large lag times, either because of large system time constants or by virtue of analyzer dead times. The controller equation is derived from the process system equations, and recognition of high-frequency and low-frequency terms points logically to the proper division between feedforward and feedback computations.

(more)

The PC-12 process control computer is opening up new fields for the process engineer in the control of industrial processes by providing an economical, reliable computer for performing a wide variety of control functions and process calculations directly in the plant. The TR-48 offers low-cost capabilities for simulating systems of all types, and for the problem solving requiring high-speed repetitive operation and iterative techniques. The PDS-1068 digital computer, manufactured by Pacific Data Systems, Inc., a subsidiary of EAI, features over 40 machine commands, a flexible interface, complete input/output electronics and 1024 words of memory. It can operate independently or under varying degrees of operator control.

Systems orientated Series 1110 solid state Variplotters will be shown plotting the input and output parameters of the simulation on the TR-48. An EAI transistorized digital voltmeter will also be incorporated in the demonstration.

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